Delta Smelt Salvage Efficiency at the Tracy Fish Collection Facility (CA): An Experimental Approach

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We propose to write a report based on the proposal that was submitted in previous years. We collected data according to those proposals. Now, we intend to write these results in the form of a Tracy Fish Collection Facility Volume Series Report. The proposal we used last year is reprinted below to refresh your memory regarding our hypotheses and approach.

Summary

The fish salvage at the Tracy Fish Collection Facility (TFCF) is accomplished in two louver channels. The primary channel has a maximum depth of 6 m (20 ft) and is completely traversed by the primary louver array which is 97.5 m (320 ft) in length and 25.6 m (84 ft) in width (Figure 1). The louver array is angled 15^{o} to the channel and has four bypasses. Each bypass is 15.3 cm (6 in) wide and leads to a primary bypass pipe 91.4 cm (36 in) in diameter. These four pipes deliver water to the secondary louver channel.

This large primary area hosts a large number of large piscivores (unpublished DIDSON observations). We hypothesize that these predators can be the most important source of delta smelt loss in the entire TFCF. Secondarily, we hypothesize that certain hydraulic conditions must be met for delta smelt Whole Facility Efficiency (WFE) to exceed 30%.

The secondary louver channel has a maximum depth of 4.9 m (16 ft) and contains two parallel louver arrays that span the channel's entire 2.4 m (8 ft) width. Similar to the primary louvers, both secondary louver arrays are angled 15° to the flow. The anterior louver array in the secondary channel ends in a rectangular opening. This steel "bypass" is 15.3 cm (6 in) in width. However, this is not a bypass to a holding tank; the steel ends 1.7 m (5.6 ft) in front of the posterior louver array's true bypass (width = 15.3 cm (6 in). A fish could be "bypassed" by the anterior secondary louver array and potentially swim

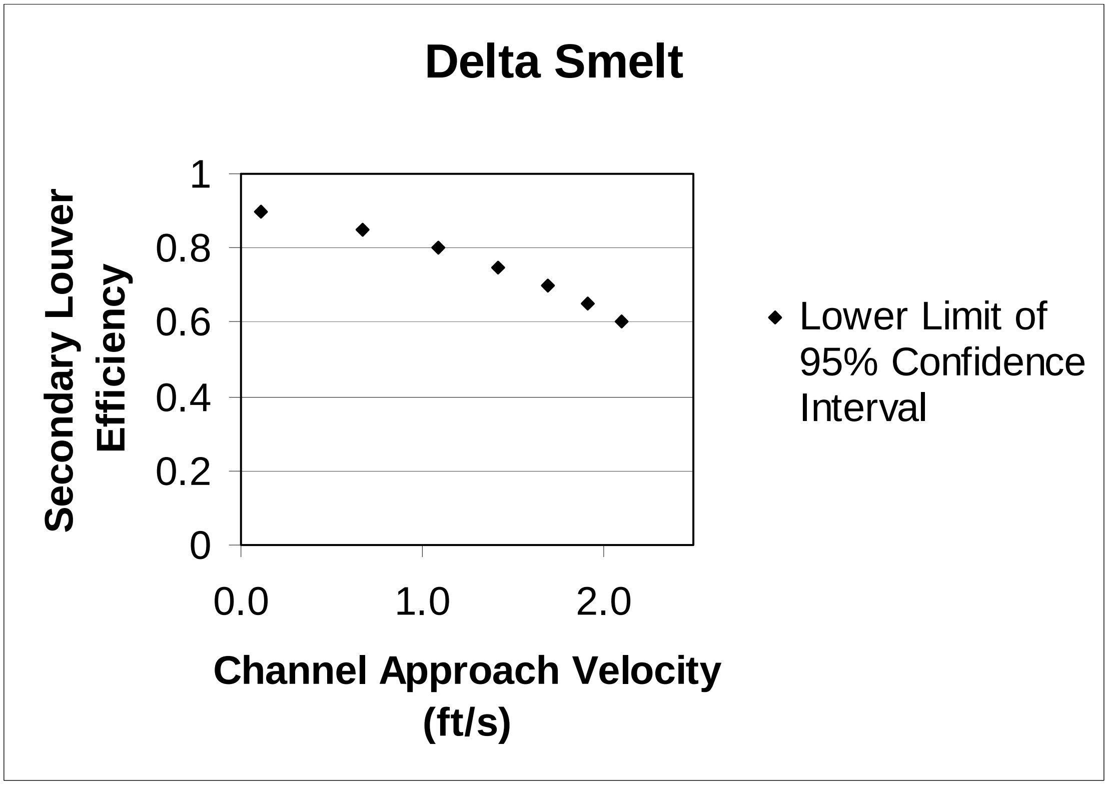

FIGURE 1.—Predicted efficiency, graphed as a proportion, from secondary channel delta smelt efficiency observations (Bowen *et al.* 2004, Figure 11). Lower line of 95% Confidence Interval of predicted efficiency is graphed.

through the posterior secondary louver array and be transported into the Delta Mendota Canal.

This smaller secondary channel area is hydraulically controlled by the velocity control (VC) pumps behind the louver arrays. We hypothesize delta smelt salvage will be higher in the secondary channel, in comparison to the primary channel, because of: (1) better hydraulic control and (2) the capacity to remove predators regularly.

Each louver array consists of a series of vertical slats each 2.3 cm (0.9 in) apart. The louver slats create a visual and turbulent barrier to fish. Most fish swim against the current but are eventually transported downstream. When a fish encounters the louver array it tends to swim laterally away from the turbulence into the more laminar flow. Thus, fish are "guided" toward the bypass. When a fish goes into the secondary bypass and enters the holding tank, that fish is considered salvaged. We have collected sufficient data to evaluate the TFCF salvage efficiency for delta smelt. This proposal is for analyses and report writing for data previously collected. This report can lead to important recommendations to improve delta smelt WFE.

Progress Update

We developed the approach described in this proposal based on previous research at the TFCF. Empirical observations showed average secondary louver efficiency for delta smelt was 65.0%. And, inspection of these results showed that efficiency went down as average channel velocity (ACV) increased. In addition, PROBIT analysis predicted that we could achieve 80% or better Secondary Louver Efficiency (SLE) if we operated with a Secondary ACV (SACV) of 0.34 meters per second (m/s) (1.1 feet per second (ft/s)) and a bypass ratio (BR) higher than 1.0.

Work prior to 2004 (Bowen *et al*. 2004) showed that insertion experiments were more effective at determining factors influencing efficiency than empirical observation. So, we began this effort to collect a number of replicates of facility efficiency at various states of average channel velocity, bypass ratio, and predator load.

To date, we have collected 68 observations of whole facility efficiency. These observations were collected over a range of Primary ACV (PACV): 0.14 m/s (0.45 ft/s) to 1.28 m/s (4.19 ft/s). In addition, they were collected over a range of Primary BR (PBR): 0.66 to 3.73. And, two experiments revolved around predator removal in the primary channel. The grand mean WFE is 23.4% (sd = 16.3%).

Problem Statement

Tracy Fish Collection Facility (TFCF) whole facility efficiency for delta smelt (*Hypomesus transpacificus*) is poorly understood. Delta smelt is a POD (Pelagic Organism Decline) species, listed as threatened, and is proposed for revision of status to endangered. Currently, information on POD species is especially important if we hope to reverse the current declining trend.

The Central Valley Project and State Water Project diversions can reduce delta smelt population size (Kimmerer 2008). A more efficient operation could salvage more delta smelt.

This research effort will provide information regarding salvage efficiency of delta smelt: (1) whole facility efficiency (WFE), (2) Primary Louver Efficiency (PLE), and (3) Secondary Louver Efficiency (SLE). In addition, we will investigate the influence of predators on primary louver efficiency. We will use this information to improve facility efficiency by manipulating operations.

Goals and Hypotheses

Goals:

1. Determine if delta smelt whole facility efficiency can be improved by predator removal, manipulating bypass ratio, or average channel velocity.

2. Determine if delta smelt primary louver efficiency can be improved by predator removal, manipulating bypass ratio, or average channel velocity.

3. Determine if delta smelt secondary louver efficiency can be improved by manipulating bypass ratio or average channel velocity.

Hypotheses:

1. The removal of predators in the primary channel will not significantly increase the delta smelt whole facility efficiency.

2. There is no difference in delta smelt whole facility salvage efficiency at different primary bypass ratios.

3. There is no difference in delta smelt whole facility salvage efficiency at different primary channel velocities.

4. The removal of predators in the primary channel will not significantly increase the delta smelt primary louver efficiency.

5. There is no difference in delta smelt primary louver efficiency at different primary bypass ratios.

6. There is no difference in delta smelt primary louver efficiency at different primary channel velocities.

7. There is no difference in delta smelt secondary louver efficiency at different secondary bypass ratios.

8. There is no difference in delta smelt secondary louver efficiency at different secondary channel velocities.

Materials and Methods

In previous years we have conducted a number of experiments in this delta smelt salvage efficiency series. We concentrated on predator reductions, Bypass Ratio (BR) and Primacy Average Channel Velocity (PACV) in various years.

To evaluate Hypotheses 2 and 4 and choose states of the PACV variable, we relied on an analysis published in Bowen *et al.* 2004. That analysis suggests that 0.34 m/s (1.1 ft/s) could produce 80% salvage efficiency (Figure 1) in a TFCF channel. Figure 1.—Predicted efficiency, graphed as a proportion, from secondary channel delta smelt efficiency observations (Bowen *et al.* 2004, Figure 11). Lower limit of 95% Confidence Interval of predicted efficiency is graphed. Eighty percent is the lower limit of the 95% confidence interval and thus the resulting efficiency at 0.34 m/s (1.1 ft/s) may be greater than 80%. We also selected PACV values varying across the range normally observed at the TFCF and included 0.70 and >0.91 m/s (2.3 and >3.0 ft/s).

Our evaluation method is experimental insertion of cultured delta smelt at three locations. We release 100 delta smelt immediately downstream of the trashrack, 40 in the secondary channel upstream of the anterior louver array, and 10 in the holding tank. We operate the holding tank and sieve net for one hour after each release. Then all delta smelt are identified and measured from the holding tank and sieve net. We use these collections to estimate the following dependent variable values: whole facility efficiency, primary louver efficiency, secondary louver efficiency, and holding tank efficiency.

These experiments are conducted at various states of the independent variables: primary average channel velocities from 0.14 m/s (0.45 ft/s) to 1.28 m/s (4.19 ft/s), bypass ratios from 0.66 to 3.73, and either no predators removed in the primary channel or after predators were removed from the primary channel. The results of these trials with the varying independent variable states and the associated dependent variable results will be used to test the eight hypotheses.

The hypothesis testing will be conducted by first evaluating the data. Principal characteristics of the date to be inspected are those of the assumptions of analysis of variance (ANOVA): independence of observations, homogeneity of variance, and normality. If the data meet all three of these observations then ANOVA will be used for the hypothesis test. If the data fail any of the three assumptions, we will rely upon non-parametric techniques (Please see the Statistical Design section below).

For each trial we used the following methodology. Delta smelt were acclimated to delta water 24 h before a trial. The fish were then placed into black buckets via water to water transfer, covered with a black lid, and moved into insertion position. Four buckets, each with 25 delta smelt, were distributed evenly across the trashrack. So, we began each trial with the release of 100 delta smelt immediately behind the trashrack to estimate WFE. Simultaneously, we will release 40 fish at the anterior end of the secondary channel to independently estimate SLE. In coordination with those two releases, we simultaneously released 10 fish in the holding tank. We inserted all 150 fish within 3 minutes of each other to begin a trial.

We actively recovered delta smelt for 3 h after the fish were inserted. During these trials salvage was directed into a holding tank while simultaneously operating the sieve net (SN). Once delta smelt were released, we recovered them through three methods: (1) fish in the holding tank (HT) are considered salvaged, (2) fish in the SN will be counted positively toward PLE and negatively against SLE, and (3) predator stomach lavage.

TFCF whole facility efficiency will be calculated as in Equation 1:

EQ (1) $$WFE = (H * H_e^{-1})/(I_P * H_e^{-1})$$

where,

- WFE = whole facility efficiency,
- H = number of fish recovered from the holding tank,
- H_e^{-1} = counting station efficiency for determining the number of holding tank fish,
- I_P = number of fish injected into the primary channel at the trashrack.

TFCF Secondary Louver Efficiency will be calculated as in Equation 2:

EQ (2) $$SLE = (H * H_e^{-1})/((H * H_e^{-1}) + (S * S_e^{-1}) + E_s)$$

where,

- SLE = Secondary Louver Efficiency,
- H = number of fish recovered from the holding tank,
- H_e^{-1} = counting station efficiency for determining the number of holding tank fish,

S = number of fish recovered in the sieve net,
S_e^{-1} = efficiency of sieve net for capturing fish inserted in the secondary channel behind the louvers, and
E_s = delta smelt recovered from stomachs of predators in the sieve net.

Primary louver efficiency will be calculated as in Equation 3:

EQ (3) $$PLE = WFE/SLE$$

where,

PLE = primary louver efficiency.

For more discussion of these calculations and assumptions see Bowen *et al.* (1998). Also, there is an unpublished white paper (Baskerville-Bridges 2005) available from Brent Baskerville-Bridges or the proposal authors upon request.

Pumping rate caused the single greatest limitation to our study. We could not change the number of pumps operating at the Jones Pumping Plant. Thus, we spent years acquiring sufficient trials at the various states of the three independent variables: primary average channel velocity bypass ratio, and predator removal. Even now, when we are writing this report we will be hampered by small sample sizes due to our inability to experimentally vary pumping rate.

Statistical Approach

Previous research has shown that when fish are inserted in groups of 30 or more the data tend to be distributed normally. However, we will evaluate these observations for normality, independence of observation, and homogeneity of variance. If the observations meet these three assumptions for Analysis of Variance (ANOVA) we will use ANOVA to evaluate the results. Planned comparisons of means will take place when the ANOVA result is found to be significant. If the data do not meet the assumptions of ANOVA we will use non-parameteric techniques, *e.g.*, Kruskal-Wallis.

Schedule

1. Data analysis — September 2010 through November, 2010
2. Draft report — Final Report Draft, December 15, 2010
3. Final report — February 15, 2010

Dissemination of Results (Outcomes, Deliverables)

We will present these results to the Central Valley Fish Facilities Review Team at one of their regularly scheduled meetings. We will distribute the report to all interested parties.

Literature Cited

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